

**Abstract:** Lawrence Berkeley National Laboratory (LBNL) is a renowned institution in High Energy Physics research and instrumentation development. The ATLAS group of the Physics Division has been deeply involved in the construction, installation, and operation of the ATLAS detector at the LHC. This paper describes the instrumentation activities in which the group is currently involved regarding the forthcoming Phase-II upgrade of the ATLAS tracker, including the silicon pixel and strip sub-detectors.

## High Luminosity-LHC and phase-II tracker upgrade for ATLAS

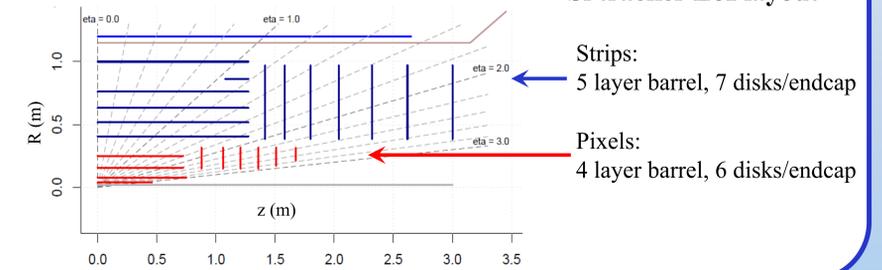
### HL-LHC (LHC phase-II upgrade):

- Energy 14 TeV
- Peak luminosity  $5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
- Integrated luminosity 2500 -3000  $\text{fb}^{-1}$
- Bunch crossing 25 ns
- ~ 150-200 interactions per bunch crossing

### Challenges for ATLAS silicon sensors

- Higher granularity to keep same low occupancy
- Higher radiation tolerance to deal with increased radiation environment
- Novel powering solutions to power efficiently x7.5 more channels
- Maintain low cable count to keep detector performance
- Reduce cost per sensor to cover larger area (~ 200 m<sup>2</sup>)

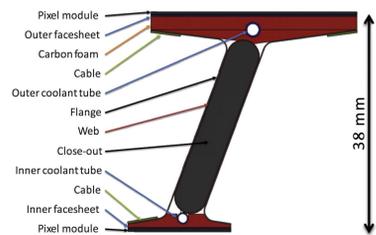
New all-silicon tracker



### Pixel detector

#### I-Beam staves<sup>[2]</sup>

- Design solution for two innermost barrel pixel layers
- 1 m and 28 cm prototypes built and mechanically tested
  - ❖  $M = 0.91 \text{ g/cm}^3$ ,  $X_0 = 0.85\%$
  - ❖ Good thermal and mechanical properties
  - ❖ Excellent parallelism between outer and inner facesheets



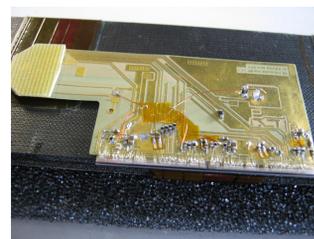
#### Flat staves

- Design solution for outermost barrel pixel layers
- Embedded bus tape and integrated EoS
- Full length 1.4 m prototype built and ready for module assembly
  - ❖ First 2-chip module mounted recently



#### Pixel modules assembly and test

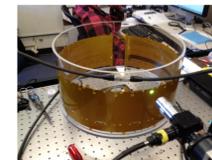
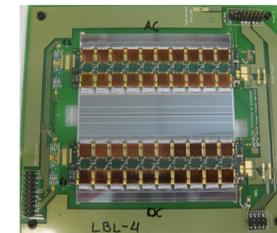
- First 2-chip module assembled (no sensors)
  - ❖ 2 FEI4B ASICs
  - ❖ FEI4A flex (Bonn)
- Ongoing electrical tests
  - ❖ DAQ: SEABASS and USBpix with 4 ports in parallel
- Tests on flat stave underway (serial power)
- Hybrids for 4-chip modules



### Strip detector

#### Strip module assembly and test

- Module assembly and electrical test
  - ❖ Noise mitigation
  - ❖ Grounding and shielding
  - ❖ Comparison of serial power and DC-DC power configurations
- Electrical test of specific components
- Up to 8 fully functional barrel modules built for the collaboration, more under way



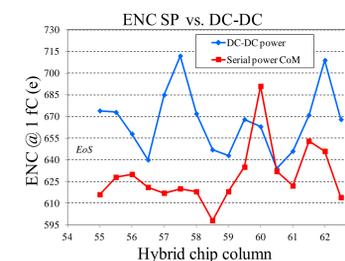
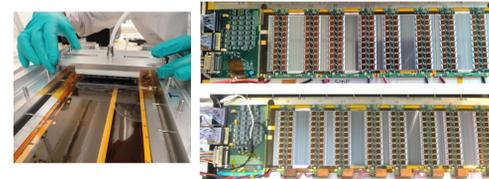
#### Bus tape measurement and co-curing

- Co-curing methods for shielded, shieldless bus tapes
- Measurements procedures for tapes and facings
- Provided co-cured bus tapes for full length DC-DC shielded stave, SP shieldless stave



#### Double-sided stavelet<sup>[3]</sup>

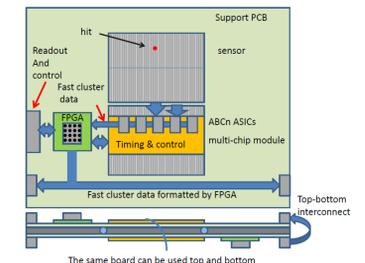
- Novel shield-less core structure with embedded bus tapes
- First double-sided stavelet
  - ❖ One side serial power
  - ❖ One side DC-DC power
- Novel assembly methods and tools developed
- Extensive thermal and electrical characterization
  - ❖ Simultaneous and synchronous readout of both sides
  - ❖ No interference between sides
  - ❖ Similar SP and DC-DC performances
  - ❖ Shield not required



### Other activities

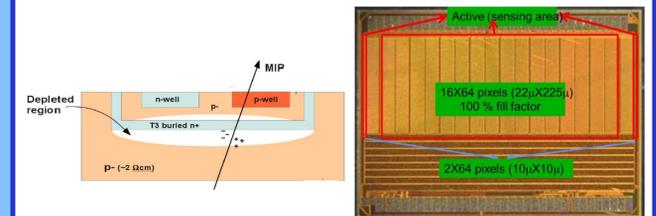
#### Self-seeded track trigger demonstrator

- Trigger promptly on momenta in 10GeV/c range by looking at correlated offsets in hits on two closely coupled axial layers
  - ❖ Fast Cluster Finder (FCF) block included on ABCN13 ASIC for strips
  - ❖ Demonstrator prototype in fabrication



#### Monolithic Active Pixel Sensors (MAPS)

- Monolithic sensors on a fully isolated substrate
  - ❖ Prototype chip fabricated on 130 CMOS
  - ❖ Two variants of pixels, both of them work



#### 65 nm CMOS technologies for future trackers

- RD53 recently established
  - ❖ M. Garcia-Sciveres co-spokesperson

#### References:

- [1] The ATLAS Collaboration, Letter of Intent for the Phase-II Upgrade of the ATLAS Experiment, CERN-2012-022, LHCC-I-023 (2013).
- [2] N. Hartman et al., Novel fabrication techniques for low mass composite structures in silicon particle detectors, in press, NIM A (2013).
- [3] S. Díez et al., A double-sided, shield-less stave prototype for the ATLAS Upgrade strip tracker of the High Luminosity LHC, submitted to JINST (2013).